POTASH BED MAPPING IN NORTHERN SAN JUAN COUNTY, PARADOX BASIN, UTAH

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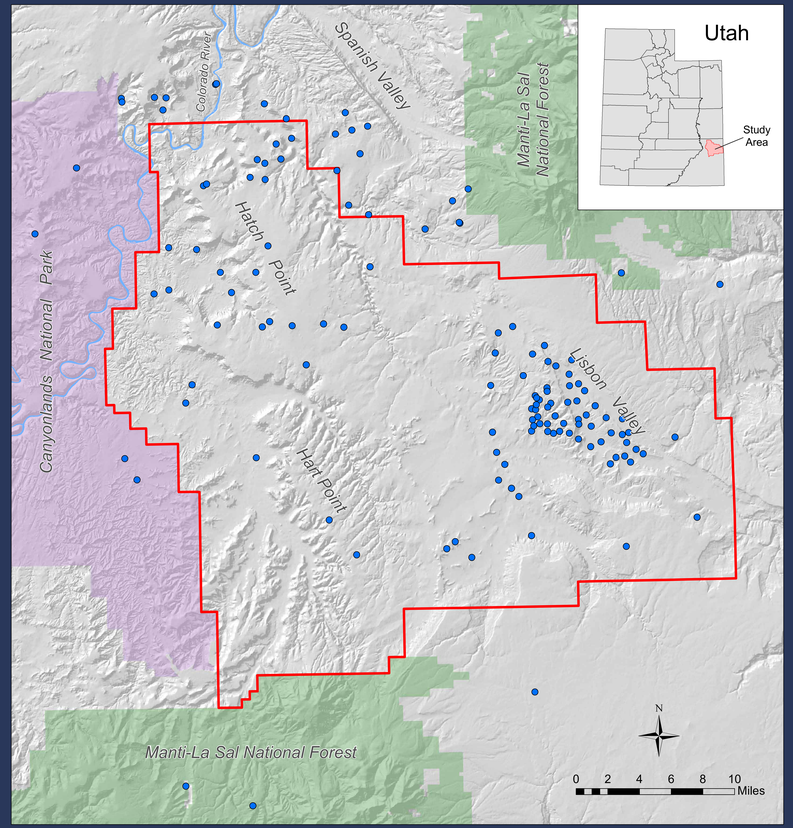
ABSTRACT

Strong international demand and high potash prices have prompted a number of companies to conduct or plan potash exploration in the already productive Paradox Basin. In response to potash interest in the area, the Utah School and Institutional Trust Lands Administration funded the Utah Geological Survey to evaluate potash beds in the Pennsylvanian Paradox Formation in about 900 square miles of northern San Juan County. The most significant potash beds in the area are in salt cycles 5, 6, 9, 13, 16, 18, and 19, and we compiled published and unpublished data on these potash beds from 132 potash and oil and gas exploration wells in and around the area. From the compiled data, which includes chemical analyses and gamma-ray log data, we created isopach, grade, overburden thickness, and structure contour maps of potash beds. For the maps, we interpolated the data using an inverse-distance-squared weighting with a northwest-trending anisotropy applied to take Paradox Basin geometry into account. Initial results suggest multiple salt cycles in the area may represent a potash resource; however, the resource comprises different beds in different areas. For example, in the Lisbon Valley area, salt cycles 5 and 9 show potash potential, whereas in the Hatch Point and Hart Point areas cycles 13 and 18 show some potential. Although overprinted and complicated by post-depositional salt deformation, our results also illustrate a shifting depocenter throughout salt-cycle deposition in the Paradox Basin.

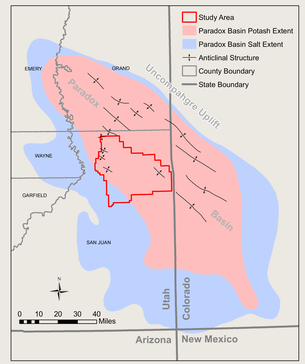
OBJECTIVE AND METHODS

The objective of this project was to evaluate the potash resources of an area in northern San Juan County, Utah for the Utah School and Institutional Trust Lands Administration. Toward this purpose, we compiled potash resource information from potash exploration drill holes and interpreted gamma-ray logs from oil and gas wells in and around the study area. We prepared a large database from the well data, and recorded potash information from salt cycles 5, 6, 9, 13, 16, 18, and 19. Database information includes depth of potash beds, interpreted or measured thickness of potash beds, potash mineralogy (sylvite, carnallite, mixed, etc.), chemical analyses or inferred grade from gamma-ray, peak API (the unit of radioactivity for natural gamma-ray logs), and data sources for the information. The spreadsheet borrowed extensively from a draft version of Massoth (2012), but other important data sources included Hodges and Banfield (1962), Britt (1977), Hite (1978), Hite (1982), Kohler (2009), and Massoth and Tripp (2011). Using publicly available data and interpretations, we selected thicknesses and grades for each potash bed of each well to use for preparation of interpolated maps in this study. The thickness we used generally represents an entire potash horizon, and is not based on an interval of a specific cutoff grade. The estimated grade is, in most cases, a maximum grade because it is based most often on peak API from gamma-ray logs. So the estimated grade for many holes is representative of only a portion of the thickness. Analytical data for the potash horizons are available in only a small percentage of the holes, and most of the analytical data are from the Lisbon Valley area. Nelson's (2007) published correlation of API and K_2O grade was helpful in selecting appropriate grade values where only gamma-ray data was available.

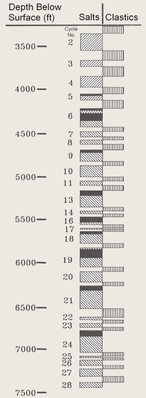
Using the potash database, we created a GIS geodatabase, which allowed for interpolation and creation of isopach, grade, overburden, and structure contour maps. We used a standard inverse-distance-squared interpolation for the maps, and applied a northwest-trending anisotropy to the interpolation to account for the shape of the Paradox Basin and the orientation of major geologic structures. ArcMap's Geostatistical Analyst was used for the interpolation.



The study area is located in northern San Juan County, Utah. The blue dots on the map represent drill holes with potash data that we used for interpolation of the potash maps.



The Paradox Basin as defined by potash and salt extents of the Paradox Formation (Hite and Cater, 1972).



The potash in the Paradox Basin is within the Pennsylvanian Paradox Formation. The Paradox Formation is composed of an evaporite sequence containing at least 29 identifiable depositional cycles, and 18 of these cycles are known to contain potash. The primary potash bearing minerals in the Paradox Formation are sylvite (KCl) and carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$).

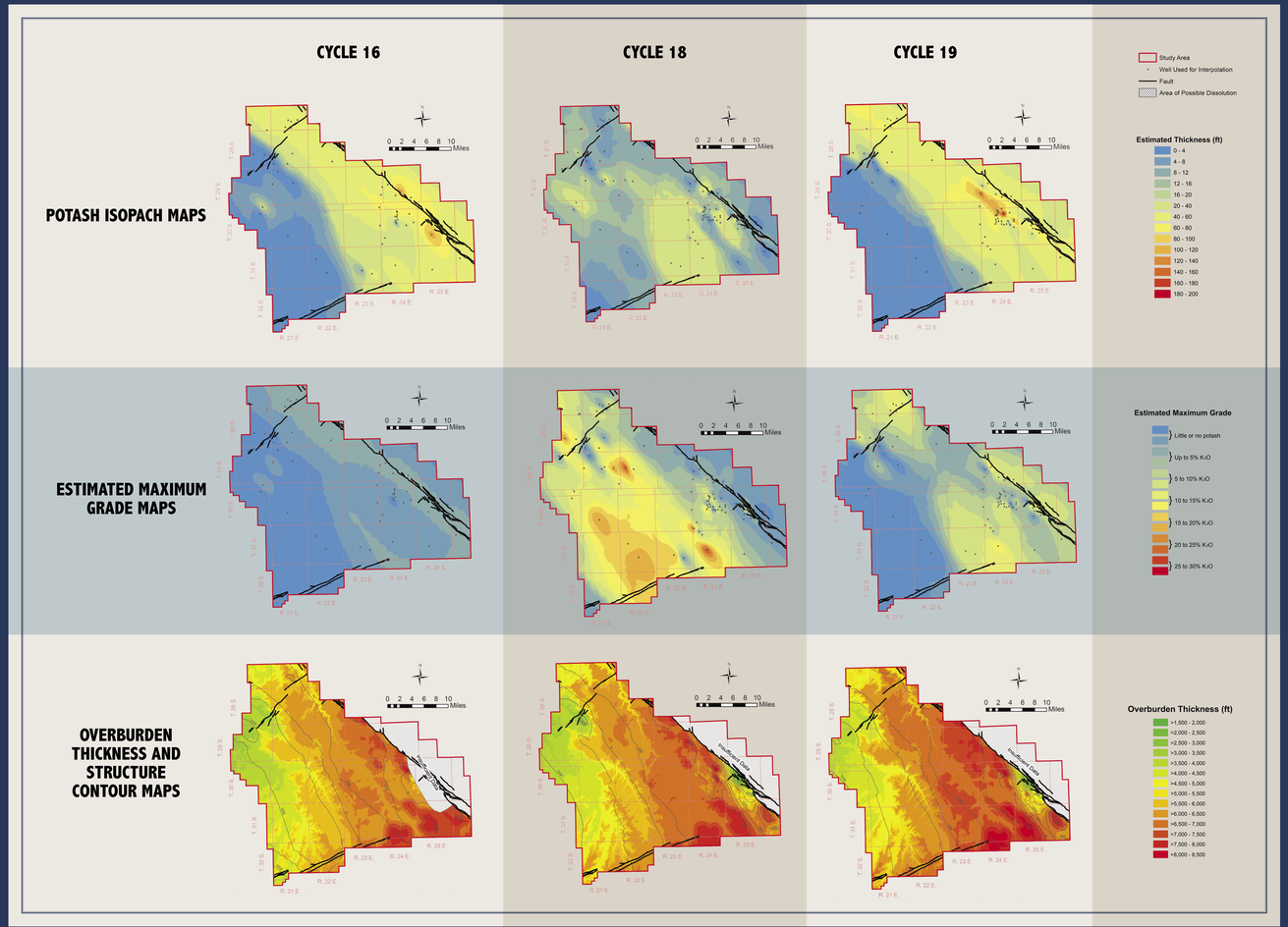
This stratigraphic column is from the Cane Creek anticline area (northeast of the study area). The diagonal hatch pattern represents halite, the vertical hatch pattern represents shaly units, and the solid black indicates the presence of potash minerals. The column is modified from Morgan and others (1991).

Intrepid Potash's operation near Moab, Utah, is located on the Cane Creek anticline. On the far left side of the photo, Intrepid's evaporation ponds are visible, and their plant is located on the right side of the photo. The Colorado River runs through the core of the anticline.

Lisbon Valley represents the eroded core of a salt anticline. The view is to the north, and the La Sal Mountains are in the background.

View showing the dramatic topographic change from the valley in the west part of the study area onto the mesa of Hatch Point, which significantly affects the overburden above the potash.

The mesa that makes up Hatch Point. The view is to the northeast with the La Sal Mountains in the background.



SUMMARY

Results from mapping potash thickness and grade suggest that a potash resource does exist in the study area. In the eastern part of the study area, particularly in the Lisbon Valley area, high grades of potash are present in salt cycles 5 and 9; chemical analyses for cycle 5 show grades above 20% K_2O, and above 30% K_2O for cycle 9. Results indicate that the lateral extent of high-grade potash in cycle 5 is more limited than in cycle 9, and cycle 9 tends to be somewhat thicker and higher grade. The salt anticline in Lisbon Valley provides the benefit of shallower potash, but adds structural complexity and likely extraction difficulty. Some of the structural complexity can be seen in the abrupt thickness changes in the Lisbon Valley. However, the additional detail in Lisbon Valley is also likely a function of close well spacing relative to the rest of the study area.

In the southwest half of the study area, mapping indicates that high grades of potash with variable thickness (generally less than 30 ft) may be present over large areas in cycle 18. One chemical analysis and gamma-ray data suggest sizable areas of better than 20% K_2O in cycle 18. A few wells also indicate that some high-grade potash is present in the west-central part of the study area in cycle 13, but it is much less extensive than cycle 18. The extents of higher-grade potash in cycles 13 and 18 would be better defined with additional exploration in the central part of the study area. Potential for expansion (or reduction) of high-grade areas in these cycles is likely. Additional study of potash mineralogy would be important for these cycles due to reports of carnallite in both of the horizons. For most of the western and southern study area, overburden is controlled by a combination of topography and the gentle northeast dip of strata. Depths to cycles 13 and 18 are shallower in the west part of the area in the valley adjacent to the Colorado River, and increase significantly to the east once under the mesas that constitute Hatch Point and Hart Point.

Cycle 19 may have some potential, but available data suggest grades that are generally lower than 5, 9, 13, and 18. Also, the areas indicating higher grades in cycle 19 are generally in areas of thick overburden.

Generally, the potash resource evaluation of the study area would benefit from additional coring and chemical analyses from potash horizons, particularly outside of Lisbon Valley, in order to calibrate grades inferred from gamma-ray responses with actual analyses. Additional exploration wells in the central and southwestern parts of the study area would also help better define any potentially economic potash zones. Insufficient data are available in these areas to interpolate thicknesses and grades with much confidence. Additional work for the area could also include a more detailed evaluation of gamma-ray logs. This study only considered the highest gamma-ray API for a particular horizon, but many of the potential potash horizons included multiple smaller peaks. For areas of interest, a valuable study could include estimating thickness and recording peak API for subhorizons within potential potash zones.

ACKNOWLEDGEMENTS

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